



# Sangamon County Solar Photovoltaic (PV) System Installation Checklist.

## Introduction to the Inspection Checklist for Rooftop Solar Photovoltaic (PV) Systems in Sangamon County

This Inspection Checklist for Rooftop Photovoltaic (PV) Systems is based on the Model Inspection Checklist for Rooftop Photovoltaic (PV) Systems.

1. **An inspection checklist serves a variety of important functions:**
2. **Educate installers** about requirements in advance, reducing the number of items that might need to be addressed afterward.
3. **Save time and resources** for both the installers and inspectors by reducing the number of re-inspections and on-site education required for new installers.
4. **Educate new and experienced inspectors** to ensure they are aware of the host of code requirements that must be verified on-site during the inspection.



5. **Increase consistency of inspections**, by both a single inspector, as well as different inspectors working for the jurisdiction to ensure high-quality, safe installations.
6. **Highlight common mistakes** or particular issues that seem to be repeatedly problematic for installers.
7. **Communicate new code requirements** simply by updating the checklist.
8. **Prevent misunderstandings** when an installer or inspector is unclear about the origin of the requirement or its exact wording.

*NOTE: This inspection checklist is not a replacement for careful review and understanding of the actual code requirements.*

This checklist is merely intended to act as an abbreviated tool, which can be used on-site for verification of compliance with code requirements and as a quick reference guide to help inspectors quickly find the correct code sections. Where there is a question about the actual language of the code section or the specificity of the requirement, both inspectors and installers should look up.



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## Inspection Checklist for Rooftop Photovoltaic (PV) Systems

All referenced Code refers to the following documents as amended by Sangamon County:

- *International Residential Code (IRC) 2018 version*
- *International Building Code (IBC) 2018 version*
- *International Fire Code (IFC) 2018 version*

### Section 1: PV Array Configuration

- ◇ Module manufacturer, make, model, and number of modules match the approved plans. (IBC 107.4)
- ◇ PV modules are listed to UL 1703. (NEC 110.3, 690.4 & IBC 1509.7.4)
- ◇ NOTE: AC modules need to be listed to UL 1703 and UL 1741.
- ◇ DC modules are properly marked and labeled. (NEC 110.3, 690.4(D) & 690.51)
- ◇ AC modules are properly marked and labeled. (NEC 110.3, 690.4(D) & 690.52)
- ◇ Modules are attached to the mounting structure according to the manufacturer's instructions and the approved plans. (NEC 110.3(B), IBC 107.4)
- ◇ Roof penetrations are flashed and counter-flashed. (IBC Chapter 15 & IRC Chapter 9)
- ◇ PV modules are in good condition (i.e., no broken glass or cells, no discoloration, frames not damaged, etc.). (NEC 110.12(B))
- ◇ Residential one and two family dwelling limited to maximum PV system voltage of 600 volts. (NEC 690.7)
- ◇ Rooftop systems are designed in accordance with the IRC & IBC. (R908 & IBC 1509.7)
- ◇ Roof access points, paths and clearances need to comply with the IFC Chapter 1204

### Section 2: Grounding

- ◇ A complete grounding electrode system is installed. (NEC 690.47(A) & (B))
- ◇ Modules are grounded in accordance with manufacturer's installation instructions using the supplied hardware or listed equipment specified in the instructions and identified for the environment, and using the grounding point identified on the module and in the manufacturer's instructions. (NEC 690.43 & 110.3(B))
- ◇ Properly sized equipment grounding conductor is routed with the circuit conductors. (NEC 690.45, 250.134(B) & 300.3(B))
- ◇ AC and DC grounding electrode conductors are properly connected. Separate electrodes, if used, are bonded together. (NEC 690.47, 250.50 & 250.58)
- ◇ Bonding fittings are used on concentric/eccentric knockouts with metal conduits for circuits over 250 volts. (NEC 250.97) (see also exceptions 1 through 4)
- ◇ Bonding fittings are used for ferrous metal conduits enclosing grounding electrode conductors. (NEC 250.64(E))



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## Section 3: Wire Management

- ◇ Wires are secured by staples, cable ties, straps, hangers or similar fittings at intervals that do not exceed 4.5 feet. (NEC 334.30 & 338.12(A)(3))
- ◇ Wires are secured within 12 inches of each box, cabinet, conduit body or other termination. (NEC 334.30 & 338.12(A)(3))
- ◇ Cable closely follows the surface of the building finish or of the running boards. (IFC 605.11.2) NOTE: see Section 12 below for additional guidance on routing of conductors for fire fighter safety concerns.
- ◇ Exposed single conductors, where subject to physical damage, are protected. (NEC 230.50(B) & 300.5(D))

## Section 4: Conductors

- ◇ Exposed single conductor wiring is a 90C, wet rated and sunlight resistant type USE-2 or listed PV wire. (NEC 690.31(B)) If the wiring is in a conduit, it is 90C, wet rated type RHW-2, THWN-2, or XHHW-2. (NEC 310.15)
- ◇ Exposed single conductors used for ungrounded (transformerless) systems are listed and identified as "PV wire." (NEC 690.35(D)(3)) For other conductor requirements for ungrounded systems see NEC 690.35(D).
- ◇ Conductor insulation is rated at 90C to allow for operation at 70C+ near modules. (NEC 310.15)
- ◇ Where conductors or cables are installed in conduits exposed to direct sunlight on or above rooftops, correction factors for ambient temperature adjustments are applied. (NEC 310.15(B)(2)(c))
- ◇ Grounded conductor is identified white or grey. (NEC 200.6)
- ◇ Open conductors are secured and protected. (NEC 338.12(A)(3) & 334.30)
- ◇ Conductors are not in contact with the roof surface. (NEC 334.30)
- ◇ DC conductors inside a building are in a metal raceway or MC metal-clad cable that complies with 250.118(10), or metal enclosures. (NEC 690.31(E))
- ◇ If more than one nominal voltage system conductor is installed in the raceway, permanent identification and labeling is required. (NEC 200.6(D) & 210.5(C))
- ◇ For underground conductor installations, the burial depth is appropriate and warning tape is in place. (NEC 300.5(D)(3) & Table 300.5)
- ◇ Aluminum is not placed in direct contact with concrete. (NEC 250.120(B) & 110.11)
- ◇ DC source circuit conductors are rated at  $1.25 \times 1.25 = 156\%$  short-circuit (ISC) current from modules. NOTE: The module ISC x number of combined strings, if strings are combined. When DC source circuits (strings) are connected in parallel the short circuit current multiplies and PV output conductors from combined strings need to be sized appropriately. (NEC 690.8(1) & (B)(1))
- ◇ PV circuit and premises wiring is separated. (NEC 690.4(B))





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## Section 5: Overcurrent Protection

- ◇ Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary. (NEC 110.3(A), (B) & 690.9(D))
- ◇ DC source circuit overcurrent protection devices are rated at  $1.25 \times 1.25 = 156\%$  short-circuit (ISC) current from modules. NOTE: The module ISC x number of combined strings, if strings are combined. When DC source circuits (strings) are connected in parallel the short circuit current multiplies DC over-current protective devices need to be sized appropriately. (NEC 690.8)
- ◇ Overcurrent protection is required for the PV source circuit (modules and parallel connected modules), PV output circuit (conductors between source circuits and inverter), inverter output circuit, battery circuit conductors and equipment. (NEC 690.9(A))
- ◇ Where three or more strings are combined, a listed combiner box (UL1741) is used and fuses are required. When DC source circuits (strings) are connected in parallel, the current through a failed circuit can be the sum of the current connected from the other strings, therefore special consideration must be taken to ensure the sum of the total number of strings minus one does not exceed the module manufacturer's series fuse rating, or conductor ampacity. (NEC 110.3(B), 690.9(A)) NOTE: There are a few exceptions where the module has a higher series fuse rating and a low ISC rating.

## Section 6: Electrical Connections

- ◇ Crimp on terminals are listed and installed using a listed tool specified for use in crimping those specific crimps. (NEC 110.3(C) & 110.14)
- ◇ Pressure terminals are listed for the environment and tightened to manufacturer recommended torque specifications. (NEC 110.11, 110.3(C) & 110.14(D))
- ◇ Connectors are listed for the voltage of the system and have appropriate temperature and ampere ratings. (NEC 110.3(C) & 110.14(C))
- ◇ Twist on wire connectors are listed for the environment (i.e. wet, damp, direct burial, etc.) and installed per manufacturer's instructions. (NEC 110.11, 110.3(C), & 110.14(B))
- ◇ Terminals containing more than one conductor are listed for multiple conductors. (NEC 110.14(A) & 110.3(B))
- ◇ Connectors and terminals used for fine strand conductors are listed for use with such conductors. (NEC 110.14(A) & 110.3(B))
- ◇ Connectors that are readily accessible and operating at over 30 volts require a tool for opening. (NEC 690.33(C))

## Section 7: Charge Controllers

- ◇ Exposed energized terminals are not readily accessible. (NEC 110.27)
- ◇ Diversion charge controllers that are used as the sole means of regulating charging of batteries have a second independent means of control to prevent overcharging. (NEC 690.72)



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## Section 8: Disconnects

- ◇ Disconnects used in DC circuits are listed for DC operation. (NEC 110.3)
- ◇ Disconnects are installed for the PV equipment. NOTE: For inverters and other equipment that are energized from more than one source, the disconnecting means must be grouped and identified. (NEC 690.15)
- ◇ Disconnects and overcurrent protection are installed for all ungrounded conductors in ungrounded (transformerless) PV power systems. (NEC 240.15 & 690.35)

## Section 9: Inverters

- ◇ Multiple PV systems shall be permitted to be installed in or on a single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with 705.10 shall be provided at each PV system disconnecting means.
- ◇ Listed AC and DC disconnects and overcurrent protection are grouped and identified. (NEC 690.15)
- ◇ The wiring system connected to a stand-alone system shall be installed in accordance with 710.15. (NEC 690.10)
- ◇ The plastic barrier is re-installed between the AC, DC wiring and communication wires. (NEC 110.3(B) & 110.27)

## Section 10: Batteries

- ◇ An energy storage system connected to a PV system shall be installed in accordance with Article 706. (NEC 690.71)
- ◇ Live parts of battery systems for dwellings are guarded to prevent accidental contact by persons or objects. (NEC 110.27 & 706.34(A))
- ◇ Flexible cables, as identified in Article 400, in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also be permitted between batteries and cells within the battery enclosure. Such cables shall be listed and identified as moisture resistant. Flexible, fine-stranded cables shall only be used with terminals, lugs, devices, or connectors in accordance with 110.14. (706.32)
- ◇ The terminals of all cells or multicell units shall be readily accessible for readings, inspection, and cleaning where required by the equipment design. One side of transparent battery containers shall be readily accessible for inspection of the internal components. (706.33)
- ◇ Battery locations shall conform to with 408.10 & 706.34
- ◇ Gas piping shall not be permitted in dedicated battery rooms. (706.34 (C) & 408.10 (F))
- ◇ Cables to inverters, DC load centers, and/or charge controllers are in a conduit. (NEC 690.31)
- ◇ Conduits enter the battery enclosure below the tops of the batteries. NOTE: this is to avoid accidental ventilation of gases into electrical equipment where sparks may occur. Follow battery enclosure manufacturer's instructions for venting and conduit locations. (NEC 110.3(B), 480.9(A) & 480.10)
- ◇ A disconnecting means shall be provided for all ungrounded conductors derived from an ESS. A disconnecting means shall be readily accessible and located within sight of the ESS. (706.7 & 240.12 (H))
- ◇ Area is well ventilated and the batteries are not installed in living areas. (NEC 408.9(A) & 408.10)
- ◇ Each vented cell shall be equipped with a flame arrester. (480.11 (A) & (B))



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## Section 11: Signs and Labels

- ◇ Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked “PV SYSTEM DISCONNECT” or equivalent. Additional markings shall be permitted based upon the specific system configuration. For PV system disconnecting means where the line and load terminals may be energized in the open position, the device shall be marked with the following words or equivalent (690.13 (B))
- ◇ Photovoltaic System Direct Current Circuits on or in a Building. Where PV system dc circuits run inside a building, they shall be contained in metal raceways, Type MC metal-clad cable that complies with 250.118(10), or metal enclosures from the point of penetration of the surface of the building to the first readily accessible disconnecting means. The disconnecting means shall comply with 690.13(B) and (C) and 690.15(A) and (B). The wiring methods shall comply with the additional installation requirements in 690.31(G) (1) through (4). (690.31 (G))
- ◇ Marking is placed adjacent to the main service disconnect in a location clearly visible from where the disconnect is operated. (IFC 605.11.1.3)
- ◇ The markings say “WARNING: PHOTOVOLTAIC POWER SOURCE” and have 3/8 inch (9.5 mm) minimum-sized white letters on a red background.. (690.31 (G (3) & (4))
- ◇ Labels are phenolic where exposed to sunlight. Labels required on conduit are permanent, weather resistant and suitable for the environment. Labels have a red background with white lettering. The following labels are required as applicable:
- ◇ A permanent label for the dc PV power source indicating the information specified in (1) through (3) shall be provided by the installer
- ◇ Maximum voltage
- ◇ Maximum circuit current
- ◇ Maximum rated output current of the charge controller or dc-to-dc converter (if installed) (690.53)
- ◇ All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means (690.54)
- ◇ Buildings with PV systems shall have permanent labels as described in 690.56(C)(1) through (C)(3). (690.56 (C (1) (2)(3))
- ◇ The output of an interconnected electric power source shall be connected as specified in 705.12(A) or (B). (705.12)

## Section 12: Fire Safety

*Note: Systems on detached, non-habitable Group U structures are not required to meet the requirements for 605.11.1 through 605.11.4 in the IFC. Examples of Group U structures include carports, sheds, Class 1 agricultural structures, private garages (IBC 312.1 as amended).*

- ◇ Rooftop mounted PV panels and modules have the proper fire classification rating. (IBC 1509.7.2)
- ◇ Roof access, pathways and setbacks shall meet a minimum spacing to provide emergency access. Exceptions:
- ◇ Detached, non-habitable structures or a 17 percent slope. (R324.6 & IFC 1204.2)
- ◇ Not fewer than two pathways, on separate roof planes from the lowest edge to the ridge and not less than 36 inches wide (R324.6.1 & IFC 1204.2.1.1)
- ◇ A minimum of 18 inches from both sides of the ridge is total coverage area is less than 33 percent and 36 inches if greater than 33 percent. (R324.6.2 & IFC 1204.2.1.2)
- ◇ No panels on a dwelling shall be placed below an emergency escape or rescue opening. (R234.6.2.2 & IFC 1204.2.1.3)
- ◇ Rooftop mounted PV panels and modules shall have a fire classification with Section IBC 1505.9 and listed and labeled in accordance with UL 1703 (IBC 1510.7)